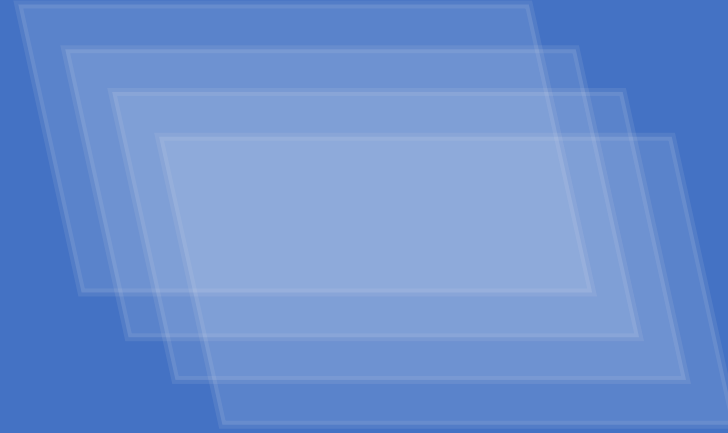
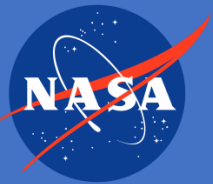


# BioCube



Integrating remote sensing and in-situ dimensions of biodiversity to understand plant and animal community composition and dynamics at large scales

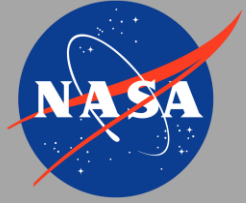
Presented by Ryan Pavlick (JPL/Caltech)



**Jet Propulsion Laboratory**  
California Institute of Technology



**WISCONSIN**  
UNIVERSITY OF WISCONSIN-MADISON



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California Institute of Technology



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**Fabian Schneider**



**Ryan Pavlick**



**Phil Townsend**



**Laura Berman**



**Ting Zheng**



**Ethan Shafron**

and Adam Chlus (JPL), Alex Turner (UW), Camila Cortez (UW Madison/JPL), John Clare (UC Berkeley), Morgan Dean (UCLA/JPL), Antonio Ferraz (JPL/UCLA), Wisconsin DNR, and many others



**Zhiwei Ye**



**Natalie Queally**



**Kyle Kovach**

## Structure



GEDI

### Functional Traits

Relative Heights  
Plant Area Index  
Foliage Height Div.  
Fractional Cover

### Funct. Diversity

FRic - Richness  
FDiv - Divergence  
FEve - Evenness  
Fbeta -  $\beta$ -diversity

## Physiology



AVIRIS>SBG, DESIS

### Functional Traits

Leaf Mass per Area  
Leaf Chlorophyll  
Leaf Phenolics  
Leaf Nitrogen  
Leaf Lignin

### Funct. Diversity

FRic - Richness  
FDiv - Divergence  
FEve - Evenness  
Fbeta -  $\beta$ -diversity

## Phenology



MODIS, SilvisLab

### Land Surf. Phen.

Greening  
Browning  
Growing Season L.

### Dyn. Habitat Index

DHI Cumulative  
DHI Minimum  
DHI Variability

## Function



ECOSTRESS, S5P, GEDI

### Hydrology

Evapotranspiration  
Water Use Efficien.  
Evaporative Stress

### Photosynthesis

Sun-Induced  
Fluorescence

### Carbon Storage

AGBiomass density

## Composition



AVIRIS>SBG, DESIS

### Spectral Features

Principal  
Components

### Spectral Diversity

Alpha Diversity  
Beta Diversity

## Environment



Various sources

### Natural

Climate  
Soil  
Topography

### Anthropogenic

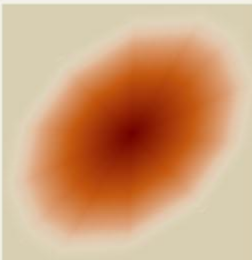
Night lights  
Human Footprint  
N Deposition

## Functional Diversity Mapping

Trait Space



Prob. Density



Fct. Diversity



## SBG Pathfinder SDS

✈️ L0 ➡ L1 ➡ L2 Reflectance

Trait  
Models



HyTools:  
Topo  
BRDF  
Modeling

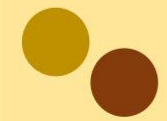
Trait  
Maps



## biodivMapR

Mask ➡ Norm ➡ PCA

Kmeans  
Cluster



Spectral  
'Species'



Alpha  
Shannon  
Beta  
Dissimilarity



# Functional Traits across Landscapes

NASA JPL AVIRIS  
Classic used to  
simulate SBG

## Leaf Mass per Area (LMA)

Leaf longevity, structure  
 $R^2 = 0.71$   
NRMSE = 13.5%

Mammoth  
Mountain

Grant Grove

San Joaquin River

Yosemite  
Valley

## Leaf Chlorophyll (CHL)

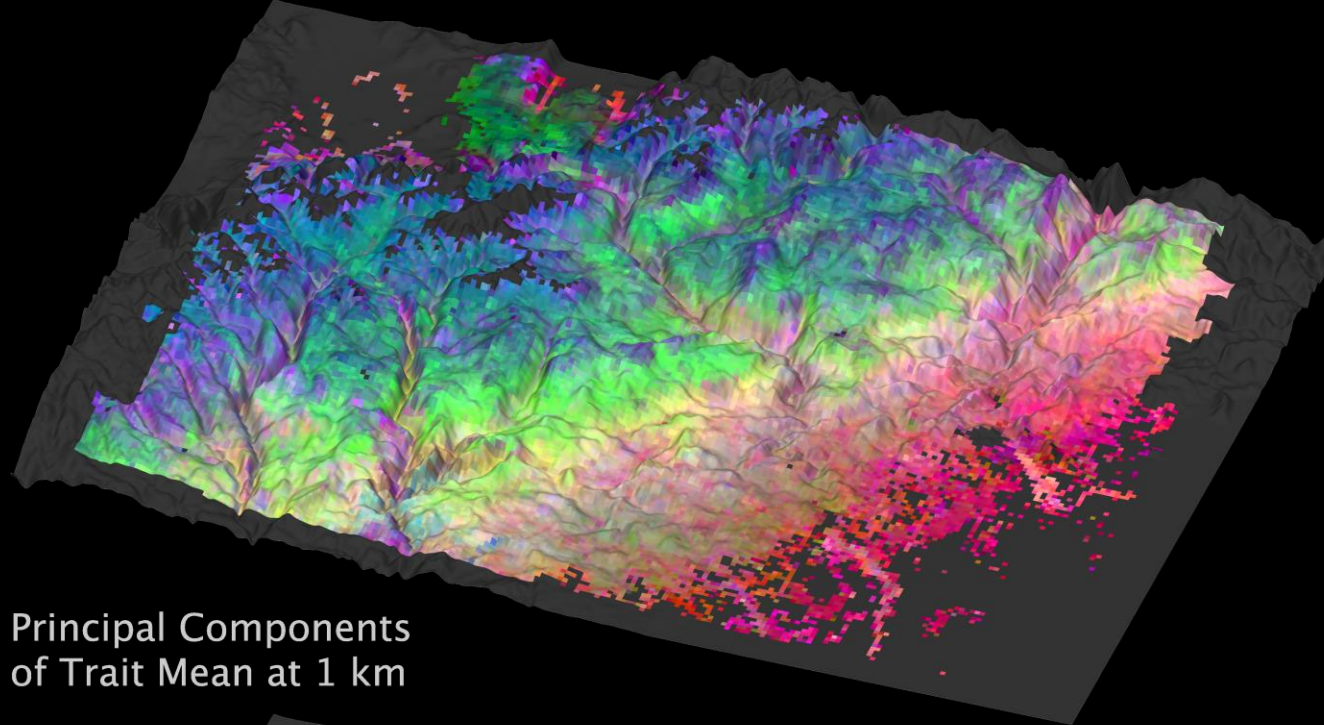
Light Capture, Growth  
 $R^2 = 0.58$   
NRMSE = 11.6%

## Leaf Calcium (CAL)

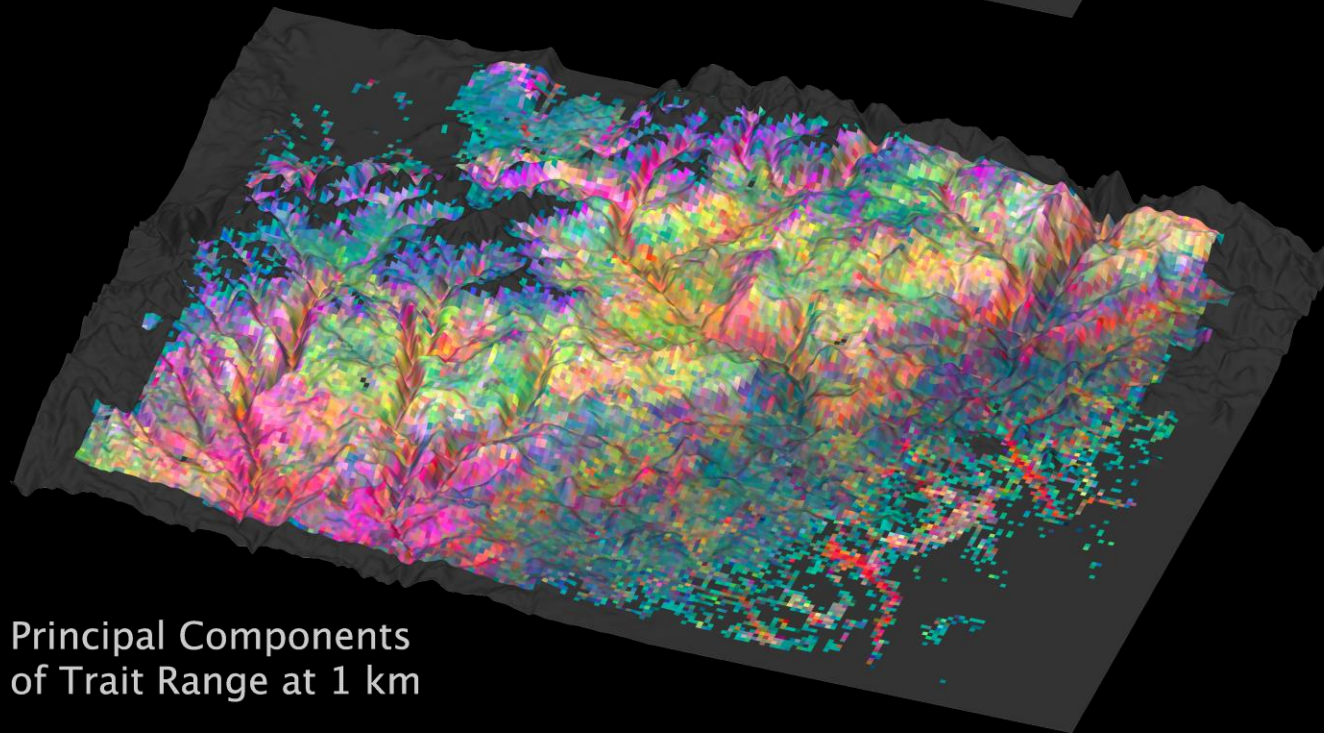
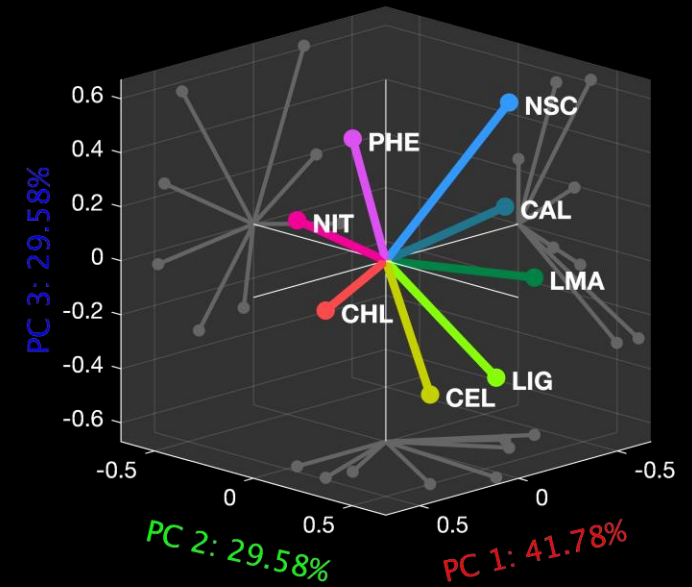
Nutrients, Metabolism  
 $R^2 = 0.25$   
NRMSE = 15%



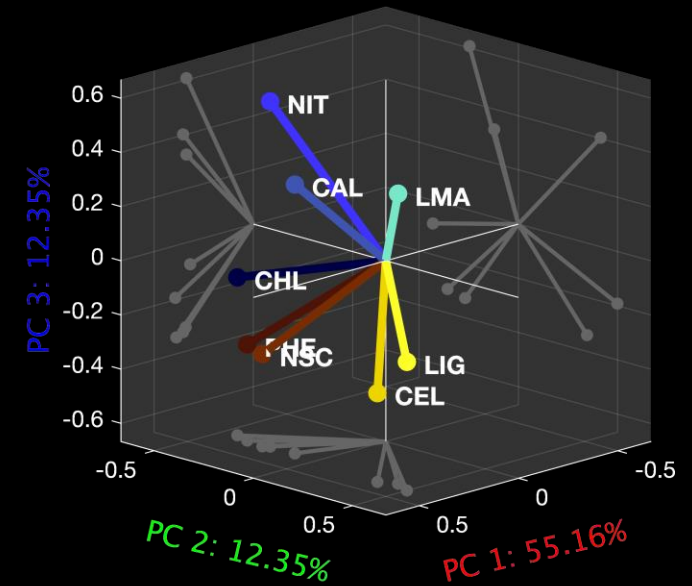




Principal Components  
of Trait Mean at 1 km



Principal Components  
of Trait Range at 1 km



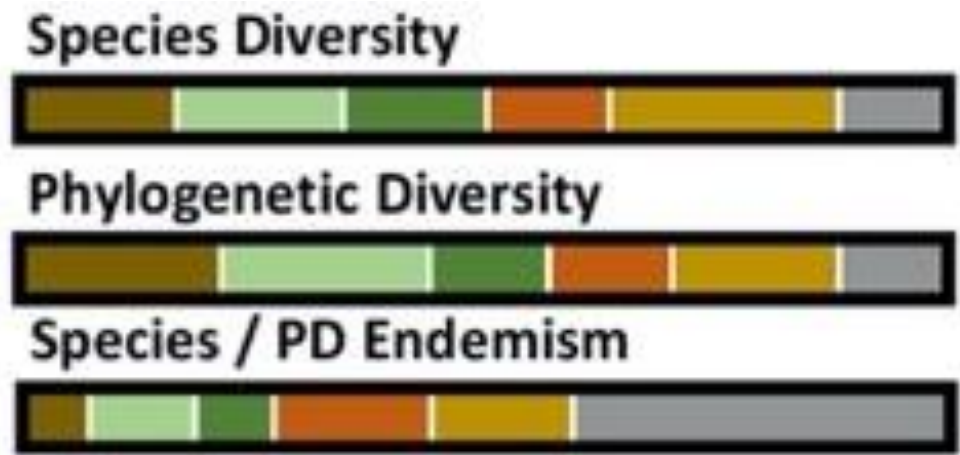
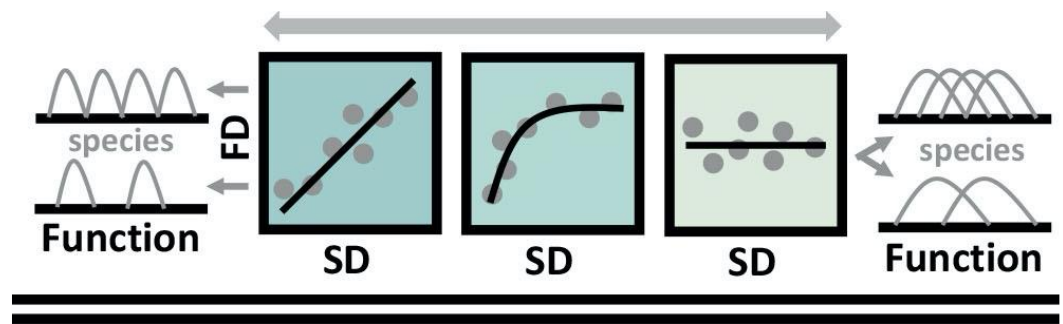
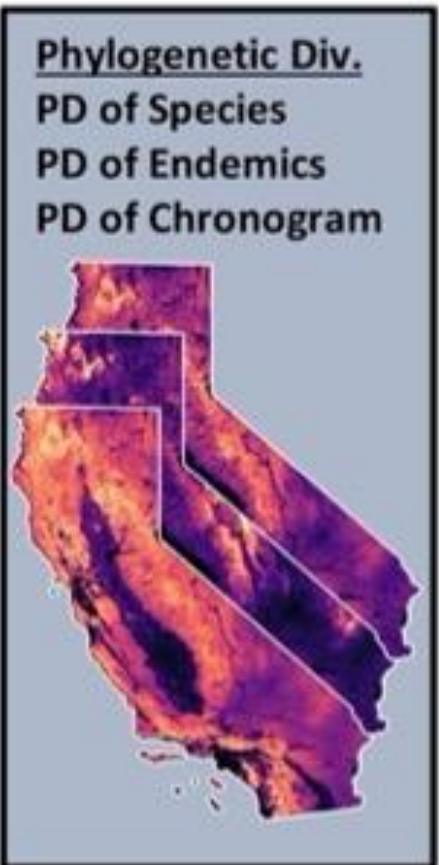
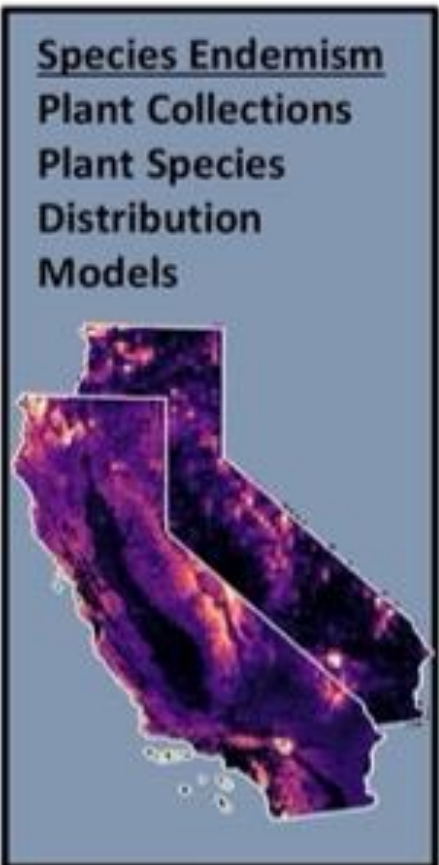
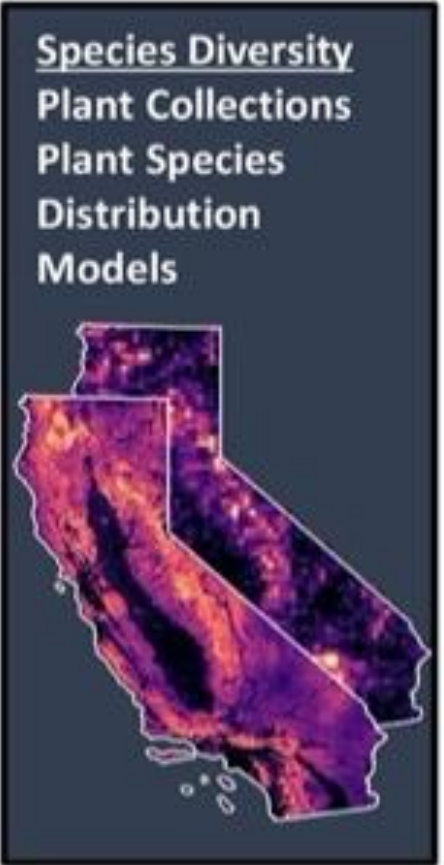
# Species



# Endemism



# Phylogeny

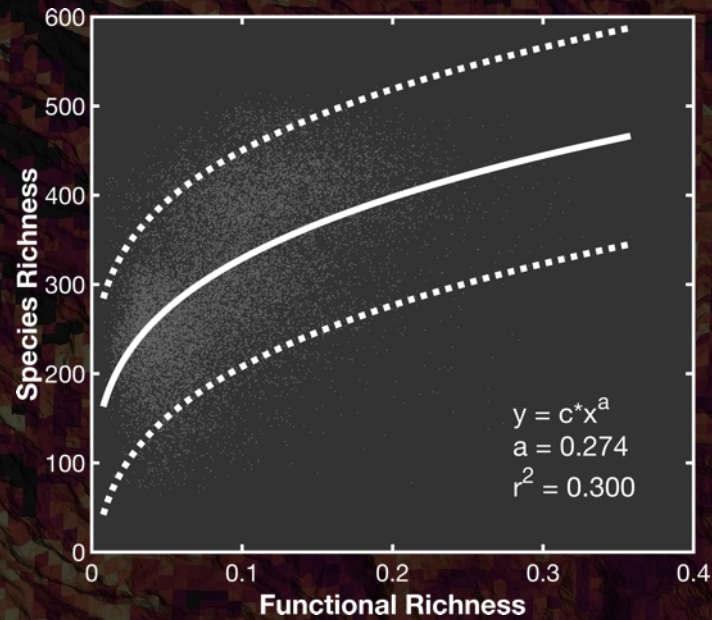
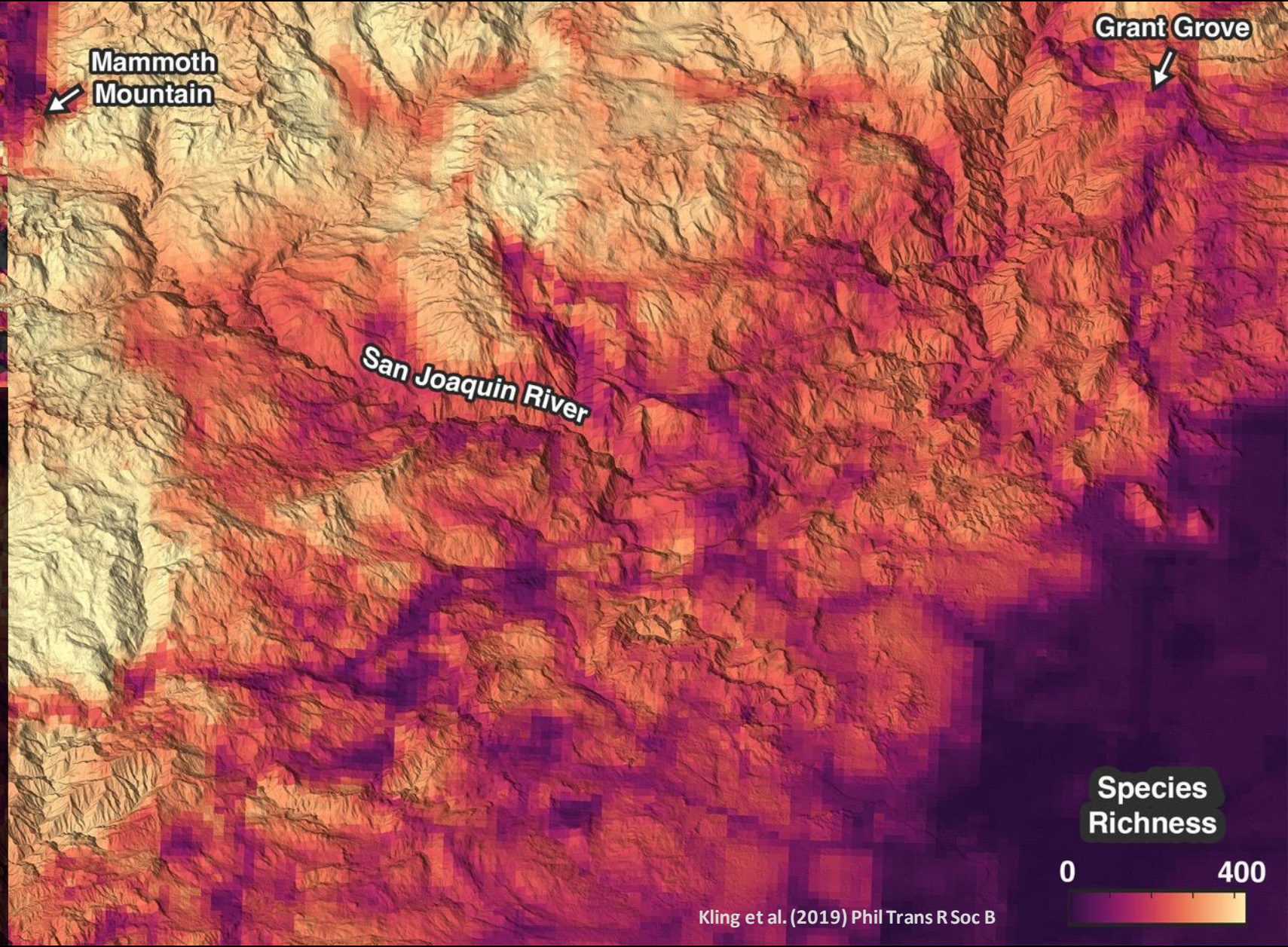
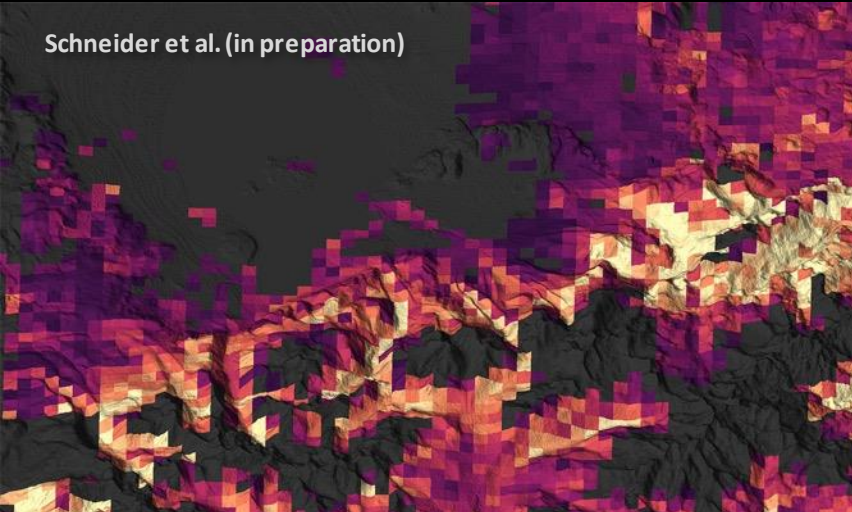


**How are dimensions of biodiversity related to each other (i.e., remote sensing and in-situ), and what is the predictability of in-situ species richness, endemism and phylogenetic diversity from space-based remote sensing data?**



# Plant Functional Richness

Schneider et al. (in preparation)



Kling et al. (2019) Phil Trans R Soc B

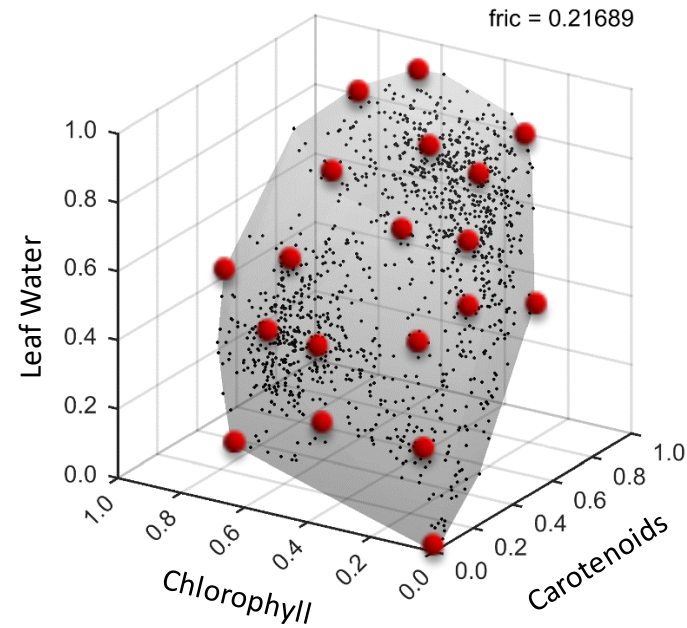
Species  
Richness

0 400

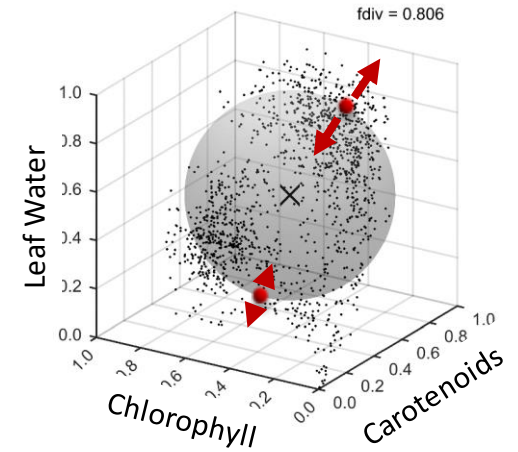


# Steps to derive functional diversity

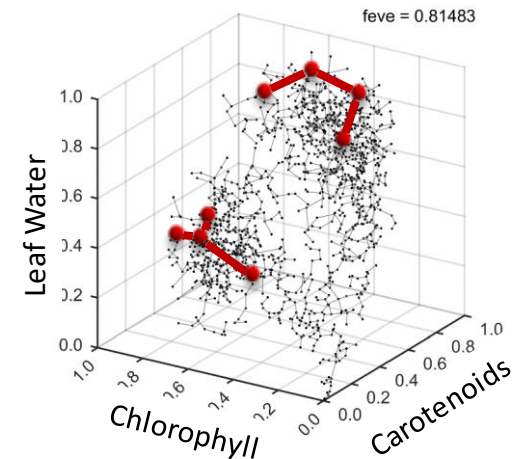
- Measure functional traits
- **Select Traits**
- Normalize Traits
- Define scales
- Choose functional diversity algorithm
  - One-dimensional
  - Multi-dimensional
- Apply algorithm
  - Moving window
  - Single grid, multi-resolution, hierarchical



**Functional Richness**

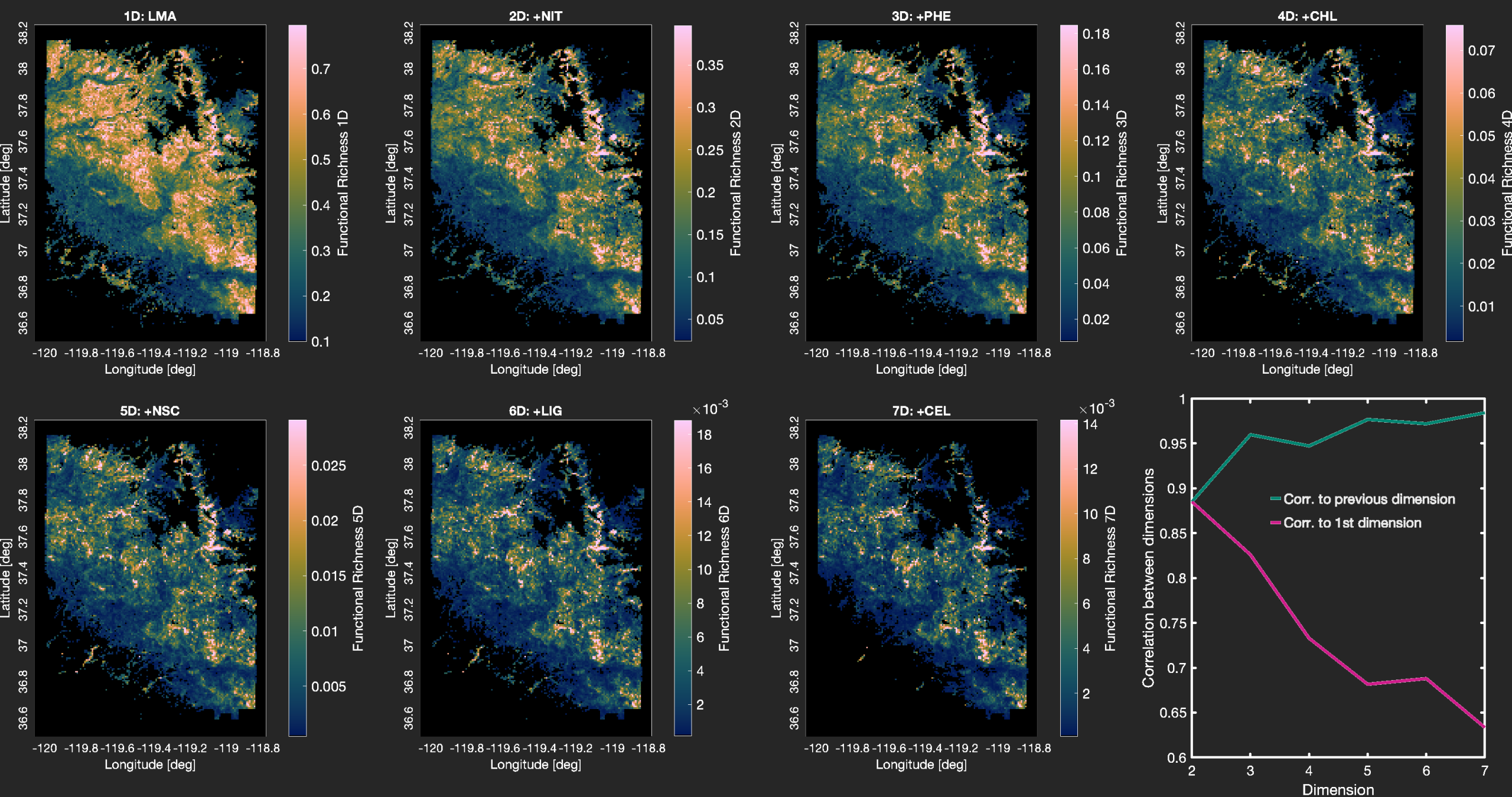


**Functional Dispersion**



**Functional Evenness**

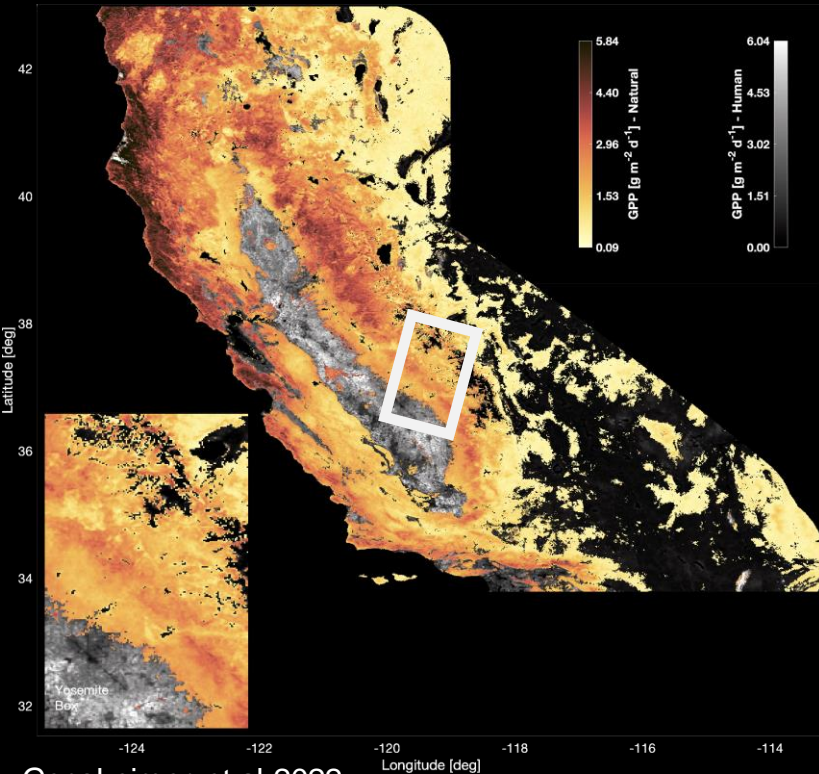




FD and its relationship to other variables can vary strongly depending on which and how many traits you consider.

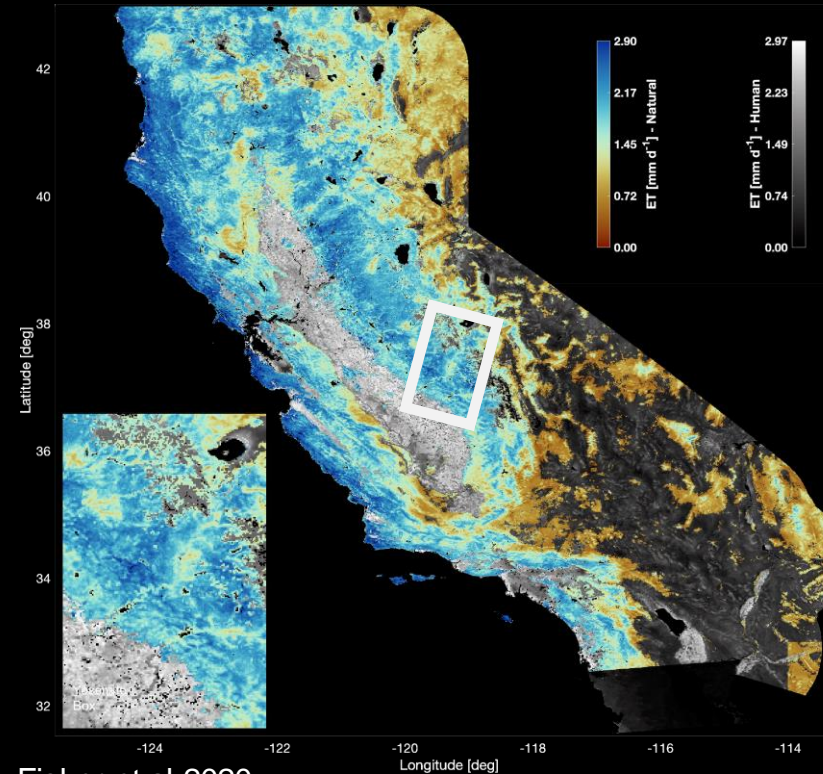


## Downscaled TROPOMI Fluorescence/Productivity



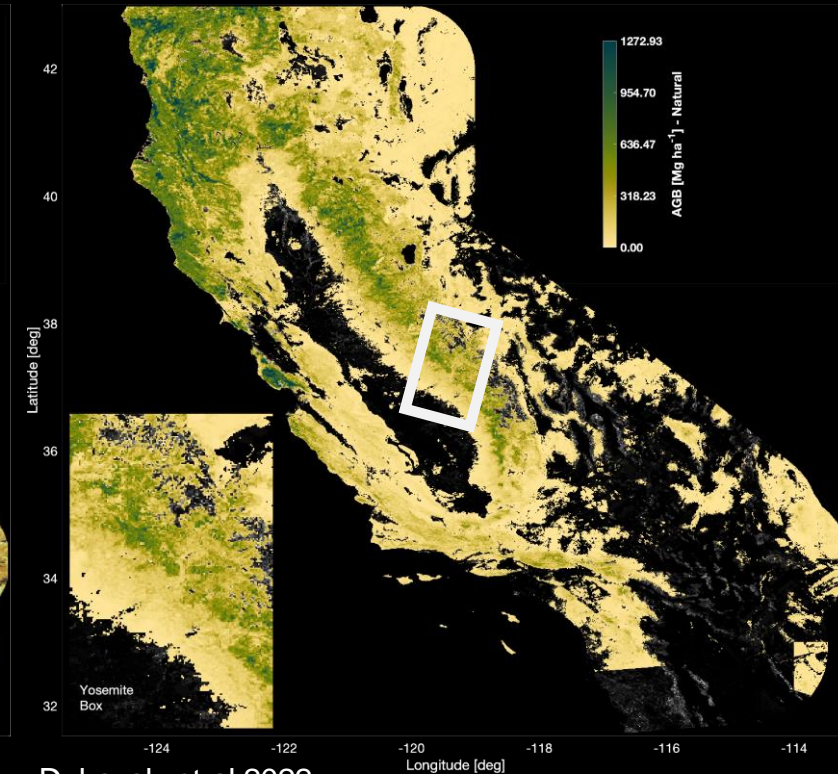
Gensheimer et al 2022

## ECOSTRESS/MODIS Evapotranspiration



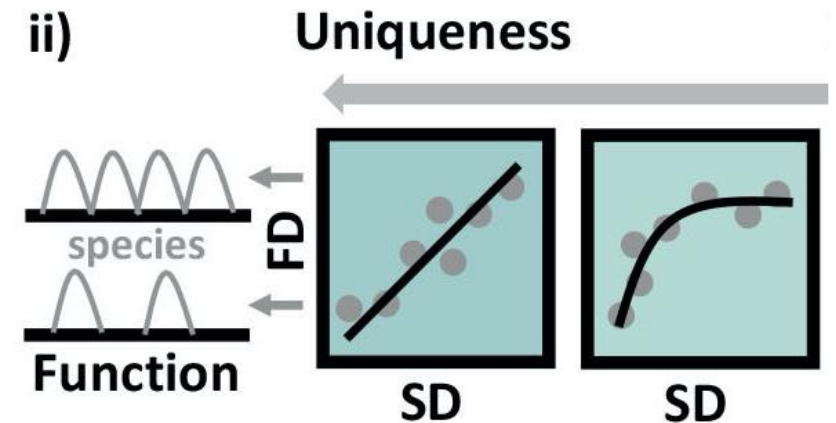
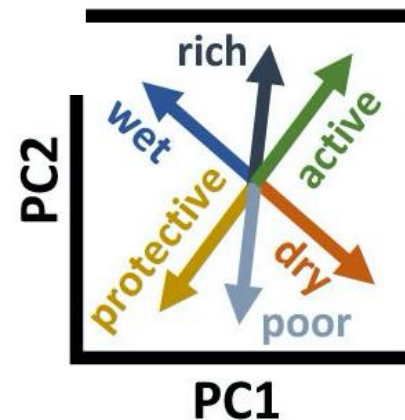
Fisher et al 2020

## GEDI Biomass



Dubayah et al 2022

What are the roles of functional, taxonomic, phylogenetic and spectral diversity in predicting the magnitude and stability of ecosystem function at large spatial scales?







4,000+  
*trail cameras*  
*1 camera/ 50 miles<sup>2</sup>*

~ 7 million  
*wildlife detections*  
*identified to species*

41  
*species*

How well do remote sensing variables predict

- species distribution
- community composition
- biodiversity
- seasonal habitat use
- circadian activity patterns

